

“He Is Just Like Me”: A Study of the Long-Term Use of Smart Speakers by Parents and Children

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Over the past few years, the technological vision of the HCI and UbiComp communities regarding conversational devices has become manifest in the form of smart speakers such as Google Home and Amazon Echo. Even though millions of households have adopted and integrated these devices into their daily lives, we lack a deep understanding of how different members of a household use such devices. To this end, we conducted interviews with 18 families and collected their Google Home Activity logs to understand the usage patterns of adults and children. Our findings reveal that there are substantial differences in the ways smart speakers are used by adults and children in families over an extended period of time. We report on how parents influence children’s use and how different users perceive the devices. Finally, we discuss the implications of our findings and provide guidelines for improving the design of future smart speakers and conversational agents.

CCS Concepts: • **Human-centered computing** → **User Studies; Empirical studies in ubiquitous and mobile computing**.

Additional Key Words and Phrases: Smart Speakers; Conversational agents; voice assistants; intelligent assistants; Google Home; personification of smart speakers

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1 INTRODUCTION

Voice-based interaction with technology has a long history of being desired, developed, and evaluated by the HCI and UbiComp communities. The smart speakers of today, such as Amazon Echo and Google Home, embody the vision of thinkers like Mark Weiser, who held that ubiquitous technologies ought to be “invisible” [39] – namely, embedded in the background of everyday life – Hugh Dubberly, who co-created the “Film Knowledge Navigator” [2], which presaged the appearance of the Internet in a portable voice-enabled device; and Homer Dudley, who developed an electronic machine that produced human speech with the Vocoder system [12]. As of early January

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of 2019, in the U.S. alone, adults own 118 million smart speakers.¹ As per industry reports between 2020 and 2022, more than 50% of households in the United States will have at least one smart speaker.^{2,3}

Therefore, now that millions of people are able to buy and use such devices, it is important to investigate how the devices are being assimilated into daily living and what challenges their users' face. Notable recent studies [1, 4, 33] have investigated how households use smart speakers; however, all these studies have examined long-term usage data only at the household level. In other words, missing from the literature is a detailed investigation of the in-home use of smart speakers over the long-term, which explores use by different members of a family and specifically by children. Furthermore, intelligent technologies such as smart speakers also invite children to think about what it means to be intelligent and conscious [11]. To date, most studies that have focused on investigating children's use of smart speakers (e.g., [11, 41]) have been based on observing of children using voice interfaces during short sessions in a lab environment. A recent study by Lovato et al. [22] investigated the questions that children choose to ask the conversational agents during first few weeks of use in a home. While this work involved interviews with pairings of parents and their children to understand the challenges in their use and their perceptions of the technology, it did not compare the use and perceptions of the adults and children nor explore changes in usage over time.

Thus, conducting in-situ longitudinal studies to investigate the use of smart speakers by different members of households (i.e., adults and children) is crucial, as they can capture how usage and perceptions are shaped over an extended period of time, including how they might be shaped by the influence of others. Therefore, in order to bridge the above-mentioned gaps, this study was guided by the following research questions (RQ):

RQ1a: How do different members of families with children use smart speakers?

RQ1b: How does use change in the long-term?

RQ2a: How do different members of a family perceive and characterize smart speakers?

RQ2b: How do parents influence children's use of smart speakers?

The self-reporting of behaviors, specifically when it is about characterizing one's own behavior over time, can be inaccurate [38]. Therefore, to address these research questions, we triangulated our understanding of the practices of families who had smart speakers in their homes by using multiple methods of data collection. That is, even though we conducted interviews with 18 families, we also collected their Google Home Activity logs to understand their usage patterns over an extended period of time. This enabled us to contextualize the activity logs based on the findings from the interviews. We recruited the participants through flyers posted on Reddit and around campus, at sites in the city's downtown area, and in local restaurants, libraries, and supermarkets.

Based on the analysis of the data, this paper makes the following contributions: First, we identify and compare the technology use practices and purposes of adults and children and highlight how their usage changes over time. For example, for adult users, music and automation were the two most frequently used command categories; however, children primarily used the devices to engage in conversations through small talk and to express emotions, and they attributed a human-like identity to devices to try to understand them as people. Second, based on the analysis of both the interview and log data, we describe how children and parents perceive smart speakers. Specifically, we observed that while young children (5-7 years old) attributed human-like qualities to the devices and developed an emotional attachment to them, older children treated them only as machines and often devised ways to test their intelligence. Finally, we evaluate the implications of our findings and offer design recommendations (where applicable) for improving smart speakers to closely fit the needs and preferences of users.

¹<https://voicebot.ai/2019/01/07/npr-study-says-118-million-smart-speakers-owned-by-u-s-adults/>

²<https://www.cmo.com/features/articles/2018/9/7/adobe-2018-consumer-voice-survey.html#gs.t5np7l>

³<https://www.nielsen.com/us/en/insights/article/2018/smart-speaking-my-language-despite-their-vast-capabilities-smart-speakers-all-about-the-music/>

2 RELATED WORK

UbiComp and HCI have a long history of investigating ubiquitous computing in the home, much of which involves investigating the conversational capabilities of ubiquitous technologies. Prior scholarship has referred to voice mechanisms with several interchangeable terms, such as, “conversational agents,” “intelligent personal assistants,” “virtual personal assistants,” “voice assistants,” and “voice user interfaces.” Most recently, voice has become the primary modality for interacting with devices such as Amazon Echo and Google Home. In this paper, we refer to these devices as “smart speakers,” which is the term used by the device manufacturers as well.

2.1 Smart Speakers

In 1990, the Intelligent Room project of MIT [5] utilized computer vision, robotics, speech recognition, and natural language processing to build intelligent technologies for a room that could be operated by voice and gestures. Other projects, like ConHome [16] and the Aware Home project [18] at Georgia Tech, have also explored the use of voice environments custom-built for specific tasks, such as initiating video calls or paging. These systems were deployed in a lab or a customized environment and were never evaluated in actual home settings over a long period of time. However, today, there are many smart internet-connected systems for homes, such as smart thermostats (e.g., Nest⁴), cameras (e.g., Nest Cam⁵), and lights (e.g., Philips Hue Lights⁶), which can be controlled by voice activation through smart speakers.

2.2 Use of Smart Speakers

The HCI community has emphasized that the use of technology at home changes over time [17]. Recently, researchers [1, 4, 33] have investigated the long-term use of smart speakers – in particular, Google Home and Amazon Echo – in diverse households. For example, Bentley et al. [4] binned user commands into nine high-level categories – automation, music, information seeking, small talk, alarm, weather, lists, time, video – based on the capabilities of the Google Home device. Methodologically, these studies analyzed command domains only at a household level, and their contextual findings were based on the preferences and challenges of only the adult users of the family. Preliminary work by Lovato and Piper [21] investigated whether and how young children used voice assistants on common digital devices – primarily mobile phones – through an online survey and an analysis of YouTube videos of children using Apple’s iOS Siri. They found that children used voice assistants to seek information (e.g., to get weather reports), to explore the device (e.g., to ask for jokes), and to perform functional tasks (e.g., to set an alarm).

Several other studies have investigated the challenges users face when using the voice assistants on smart phones or smart speakers. Luger and Sellen [23], investigating the use of the voice assistants on phones, found that there is a considerable gap between user expectations and the practical realities of use, which leads to an economy of interaction and/or gradual abandonment due to frustration. Pradhan et al. [30] noted that users with visual impairments faced challenges in command discoverability, and those with memory loss encountered difficulties with remembering commands for interacting with smart speakers. Furthermore, children have been found to be unable to communicate with smart speakers in the same way as in, human-to-human conversation, due to factors such as vocal cadence and accent [3, 29, 33], which in turn leads them to employ various communication repair strategies when a conversation with a device failed. Through an analysis of activity log files that captured the in-home usage of children 5-7 years old who were using Google Home to ask questions on different subjects (e.g., culture, science and culture, math, language) for the first time, Lovato et al. [22] found that children faced challenges such as understanding complex and nested information within a conversational agent’s response.

⁴<https://nest.com/thermostats/nest-learning-thermostat/overview/>

⁵<https://nest.com/cameras/nest-cam-indoor/overview/>

⁶<https://www2.meethue.com/en-us>

While these studies are significant for understanding children's initial use of voice assistants, they do not analyze longitudinal data from a wide variety of participants. Therefore, our work aims to contribute to the literature by investigating how different members of a family, including children, use smart speakers in everyday life over an extended period of time, and how their use behavior and practices might change as they grow more habituated over time.

2.3 The Personification of Smart Speakers

Smart speakers have several affordances that incline users to personify them [31, 33]. First, to interact with speakers like Google Home, users must use their voice, which lends human-like traits to the device. After a comparative analysis of Alexa, Google Assistant, Microsoft Cortana, and Apple's Siri, Lopez et al. [20] found Google Home's voice to be endowed with the highest level of human-like tone and pacing. Second, smart speakers are designed to possess a name, gender, and a personality (e.g., the ability to generate humorous responses that make conversation more engaging), which might lead users to attribute anthropomorphic characteristics to the device [23, 32]. For example, Turk [36] noted that many people have emotional interactions with Alexa (e.g., I love you, Alexa), which might be indicative of the emotional connection that users establish with the device as they personify it. Finally, these speakers co-inhabit intimate spaces (e.g., homes) with the users and therefore have been found to possess the capability to alter their dynamics as they become integrated into various activities in the domestic sphere [28, 31].

However, other studies [11, 19, 31] that have investigated the personification of smart speakers, have used self-reported user data or in-lab observations, and present divergent findings. For example, Purington et al. [31], who explored users' personification of Alexa by analyzing the content of user reviews of Echo's Alexa posted on the Amazon.com website, found that households with children or other family members who interacted with the Echo were more likely to personify the technology than single users, and even assigned it the role of a companion. Druga et al. [11] based on an in-lab experiment with children aged 3 to 10 interacting with Alexa, Google Home, and other autonomous toys, found that children's attribution of intelligence to the devices was influenced by the agent's ability to speak and by the form of the device (e.g., its having a face versus being a cylinder) and played a significant role in the interaction. However, an in-situ diary study by Lopatovska and Williams [19] found that the majority of participants, including children, did not personify the devices, while personification by others was attributed to what Nass and Moon call "over-learned social behavior" [25], whereby users interact via socially mindless responses without meaning anything by them.

We aim to contribute to the literature by determining how different members of a family perceive Google Home (i.e., how personification of the device unfolds "in the wild"), what factors influence perception and personification (e.g., the perceived intelligence [23], emotional connection [36], and interactive and affective capabilities [9] of the device), and what types of roles users assign to these devices (if any).

2.4 The Role of Parents in Children's Use of Smart Speakers

The use of technologies by children is often accompanied by parental fears about their impact. Therefore, parents often engage in *parental mediation*, the practice of overseeing a child's use of, and exposure to, technology [8]. Prior work has found that, in the same way that parents influence children's interactions with and perceptions of other people by guiding their attention, expressing opinions, and modeling interactions, parents directly impact young children's use and perceptions of technology by encouraging, discouraging, or limiting their use [15, 26, 34, 35, 37]. Garg and Moreno [13] found that social relationships and power dynamics (e.g., young children versus parents, older adults versus an adult child), the priority of each users' tasks, and pre-established technology rules influenced the shared use of smart speakers by parents and children. Researchers have also found that parents play a crucial role by suggesting or modeling repair strategies when children experience

communication breakdowns while interacting with smart speakers [3, 7]. As smart speakers continue to become deeply interwoven into the daily lives of families, we contribute to the literature by examining how parents, in their own right and through their use and perceptions of smart speakers, influence children’s use and perceptions of the devices.

3 METHOD

To understand how families with children use Google Home, we conducted interviews with 18 families to investigate their use of voice assistants. After collecting permissions from all members of the households, we also collected their Google Home activity histories—automatically generated voice logs of commands—to analyze patterns of use by different members of the household. The research was approved by our institution’s Institutional Review Board.

3.1 Participants

The participants were recruited through flyers posted on several subreddits (e.g., r/GoogleHome, r/HomeAutomation) of Reddit, around campus, at sites in the city downtown, and in local restaurants, libraries, and supermarkets. Since we were interested in learning about the use of smart speakers by families with children, we selected participants (1) if they owned at least one Google Home speaker, and (2) if they had at least one child who actively used the device(s). Overall, we received interest from 121 respondents; however, not all of them fulfilled these two criteria, or in some cases, when they qualified (33 respondents out of 121), at least one member of the family did not agree to share their Google Home logs with us.

In the end, we had a pool of 25 qualified respondents, carefully selected to ensure that our final sample represented a wide spectrum of family life (e.g., different ethnicities, states of residence, family size, number and ages of children in the family) and that all had owned a smart speaker for six months to two years prior to the study. Furthermore, the data collected from logs and interviews were analyzed on an ongoing basis, and new participants were sought until theoretical saturation was reached [24]. This process not only improved our understanding of the participants’ perceptions and use, but also helped us improve the probes to be used in future interviews. We noticed data saturation developing (i.e., logs and interview responses becoming repetitive) with our last few participants; therefore, we recruited only 18 families, even though others had expressed interest. Family sizes in our final sample ranged from two to five members (see Table 1), and all of the families had at least one child between the ages of four and 17 living in the home. Two families were bilingual – all of the members either spoke both English and Spanish or English and Hindi in their homes. The participants were provided with a twenty-dollar Amazon.com gift certificate as a token of appreciation for their participation.

3.1.1 Selection and Participation of Children: The child participants were recruited through their parents, who volunteered to participate by responding to recruitment flyers posted online and at other venues (cf. Section 1). We obtained both parental consent and assent from children before collecting children’s Google voice logs and conducting interviews with them. While soliciting the children’s assent, we explained that they, along with their parents, would be requested to provide us with the Google Home voice logs of the family and participate in an interview. We also shared with children (as we did with parents) the purpose of the research, their role in the study, and the type of questions we would be asking during the interview (e.g., about age and usage patterns), and we explained that the interview would be audio-recorded and the raw recordings, along with the Google Home logs, would be destroyed once the transcription and analysis were complete. We also informed them that their participation was voluntary (i.e., they did not have to be in this study if they did not want to be, even if their parents approved) and that they could stop if they decided to do so, even after the study was underway.

Table 1. Roles, ages, and ethnicities of participating family members. (Note: M indicates male, F female, HI an in-home interview, and RI a remote interview.)

Family ID	Ethnicity and State of Residence	Family Composition	# of Google Home devices, Length of Ownership of 1st device	Interview Mode
F1	White, Texas	Father (40); Mother (38); Children (M:11, F:6)	5, 18-24 months	RI
F2	White, Maryland	Father (28); Mother (27); Child (M:5)	1; 6-12 months	HI
F3	African-American, North Carolina	Mother (48); Child (F:11)	2; < 6 months	HI
F4	White, Tennessee	Father (36); Mother (35); Children (M:8, F:13)	1; 18-24 months	RI
F5	African-American, California	Mother (45); Child (F: 14)	1; 18-24 months	HI
F6	Asian, North Carolina	Father (37); Mother (37); Child (F: 11)	1; < 6 months	HI
F7	White, New York	Father (41); Mother (37); Children (M:10, F:6)	3; 18-24 months	HI
F8	Asian, Virginia	Father (45); Mother (41); Children (M:8, F:9)	1; < 6 months	HI
F9	White, New York	Father (45); Mother (44); Child (M: 13)	1; 12-17 months	HI
F10	White, New Jersey	Father (36); Mother; (30); Children (M: 8, F: 7)	2; 12-17 months	HI
F11	Hispanic, Pennsylvania	Mother (45); Child (F: 14)	2; < 12 months	HI
F12	White, South Carolina	Grandmother (65); Father (43); Mother (40); Children (M:8, F:5)	2; 12-17 months	HI
F13	African American, Georgia	Father (35); Mother (33); Child (F: 15)	1; 18-24 months	RI
F14	African American, New Jersey	Father (48); Mother (41); Child (M: 10)	1; 6-12 months	HI
F15	White, New York	Father (41); Mother (43); Child (F: 13)	1; 18-24 months	HI
F16	Asian American, New York	Father (38); Mother (36); Children (M: 13; F: 6)	1; 12-17 months	HI
F17	African American, Florida	Father (35); Mother (34); Child (F: 8)	3; 6-12 months	RI
F18	White, New Jersey	Father (30); Mother (29); Child (M: 6)	5; > 24 months	HI

3.2 Data Collection

3.2.1 Google Home Logs. The families shared with us their full device usage logs from the profiles of all members of the household. Overall, we collected the logs of 34 adults and 25 children. To understand the use of smart speakers at the household level, following the approach of Bentley et al. [4] (who collected the logs of early adopters, less than a year after the launch of Google Home), we provided detailed instructions to the participants

on how to access, filter, and download the activity histories of their Google Home devices from their Google accounts. We gave them the prerogative to exclude any logs they did not wish to share with the research team. Also, as raw voice files could contain sensitive or private identifiable information, we informed the participants that these would not be shared online or with any other audience besides the research team and would be destroyed once the analysis was completed.

3.2.2 Interviews. After collecting the logs, we used a semi-structured interview protocol to interview the families. While most (15) of the interviews were conducted face-to-face in the homes of the participants, three families were interviewed remotely due to logistical constraints. The children and parents were interviewed separately to ensure that no information was withheld because of each other’s presence. The interviews were audio-recorded and transcribed for analysis. In the case of the remote interviews, the parents helped the children to connect to us online and then left the room for the interview.

We started each interview by asking the families (adults and children) about how they used their voice assistant(s) domestically on a daily basis and how their home environment impacted their use. With respect to the use of smart speakers, we probed the families’ preferences; their technical knowledge; most/least complex and most/least frequent tasks; positive/negative experiences using the devices; manner, reasons and purposes for use; and perceived benefits/limitations. We also asked the children to introduce us to the device’s functionalities, benefits, disadvantages, and to tell us how they felt about using the device. We also inquired about the parents’ use with and around children, including their experiences, thoughts, and concerns, and the role they played in regard to their children’s use. The median length of the interviews was 51.5 minutes, with a standard deviation of 8.5 minutes.

3.3 Data Analysis

The activity history of a Google Home device for each profile consists of a HTML page with a list of all the commands given by a user and the corresponding raw audio files. This enabled us to identify the specific family member who gave a command. For the analysis, we used the Python Pandas library to convert the command texts and time stamps from the HTML pages to text log files. We approached the analysis of the command logs and interviews using grounded and qualitative methods [10].

To identify the command domains, the logs were coded following a semi-open coding procedure, using the command categories developed by Bentley et al.[4]. In addition, we performed open coding and identified other command categories that emerged repeatedly. Overall, the coding of the command logs occurred in two phases. In the first phase, the authors individually coded the log files of two users in one of the families. After that, the authors worked together to discuss and refine the code book to reach a high level of agreement (Cohen’s Kappa 0.94). In the second phase, the first author coded the logs of nine families, while the second author coded the remaining command logs using the code-book developed in Phase 1. The authors discussed and refined the coding scheme after coding the data from each participant. At the end, the contents of the command logs of the participating families were categorized into 29 command domains.

The interviews were analyzed using an inductive process, whereby the first author iteratively coded the interview transcripts, discussing the emerging codes with the co-author after each iteration. Atlas.Ti, qualitative data analysis software, was used for this purpose. The broad themes that emerged during the analysis included differences in use by different family members, the influence of parents on children’s use of smart speakers, children’s perceptions of smart speakers, and the nature of their interactions with the devices.

4 RESULTS

This section presents the findings of our study. We start by describing and comparing the main uses of Google Home by the different members of the households. We then explore how use by family members changed over

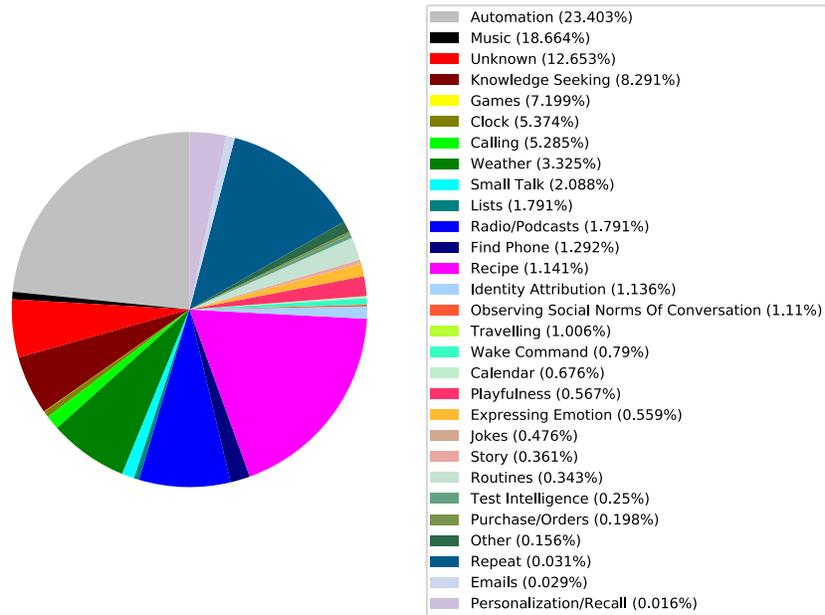


Fig. 1. Breakdown of Command Categories on Google Home.

time. Finally, we present the perceptions that the families had of Google Home, in terms of its human-like capabilities, such as personality and intelligence.

4.1 The Families' Use of Google Home

In order to understand how these devices are being integrated into people's homes and lives, it is useful to begin by looking at overall daily usage. We collected a total of 38,465 commands from Google Home activity histories, running from May 8, 2017, to April 12, 2019. Of these logs, 12.65% were marked as unknown, as they were not transcribed in *Activity History* nor were their audio files captured. We excluded these logs from the final dataset for the analysis. On average, the datasets for our 18 families span 58 weeks. During weeks when they used their speaker, the families issued, on average, 37 commands, with a median of 32 commands per week. Furthermore, the command logs were organized into 29 command categories, such as Automation, Clock, Knowledge Seeking or Search, Maintaining Lists, Calling, Playing Games, Calendar, Weather, and so forth, as shown in Figure 1.

Adults' Use: As depicted in Figure 2-4, usage by the adults differed from that of their children. Automation and Music commands were the two command categories used most frequently by the adult members of most of the participating families (cf. Figure 2-3). Automation included commands for controlling other devices or IoT systems, such as smart lights (e.g., Phillips Hue Lights), thermostats (e.g., Nest), and cameras (e.g., Nest Cam). Music included commands that users gave for playing music based on the name of a song, artist, or album name and/or through other services such as YouTube or Spotify. As reported by Ammari et al. [1], the playing of music was often related to a person's daily routine. For example, people often played ambient sounds⁷ to relax or sleep.

Being able to play music in a hands-free mode was one of the most cited reasons for adopting Google Home, whereas being able to centrally control other devices in the home did not figure as a reason for most families.

⁷<https://support.google.com/googlenest/answer/7364558?hl=en>

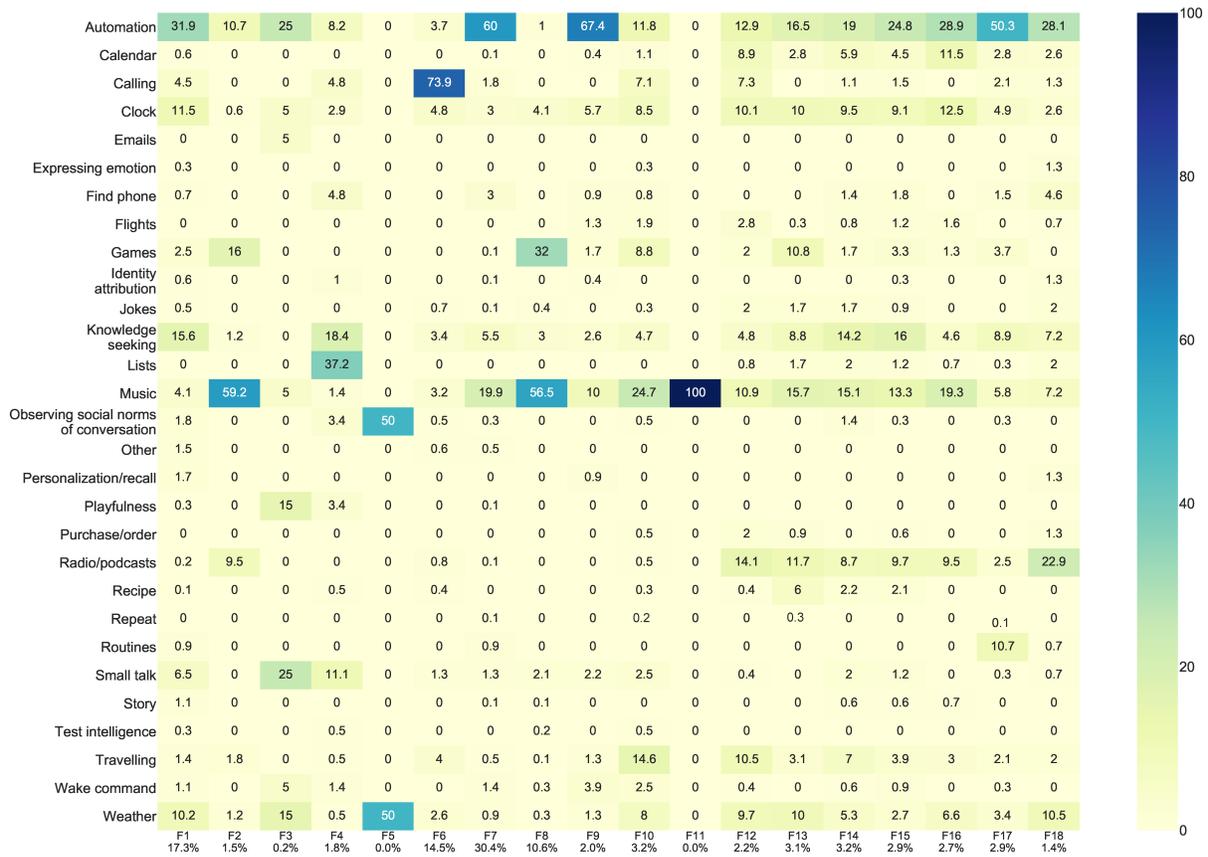


Fig. 2. Breakdown of Google Home Use by Fathers. (Note: The percentages displayed at the bottom of the table were calculated based on the ratio of the number of commands given by a specific father to the total number of commands given by all of the fathers [12,515] in our dataset.)

Therefore, while playing music on Google Home was prevalent throughout the period of ownership in most families, the practice of controlling other devices with Google Home developed over time as a family invested in smart home appliances that could be integrated with the system. For example, the father in family 18 (F18) explained that originally they purchased the device because they were looking for a Bluetooth-connected speaker for listening to music, but soon after the purchase of Google Home, the family bought many other smart devices. He noted,

All the other smart devices in my place, such as Chrome cast, Nest, fan, light, security system are connected to Google Home. I can not imagine managing or using all these devices without the voice commands that Google Home allows me to use. In short, my house is functioning because I have Google Home placed everywhere in my house.

A few families (F1, F3, F7, F17) bought Google Home so that they could control their other smart home devices through a single device instead of managing them through multitude of applications. For example, the father in F1 noted,

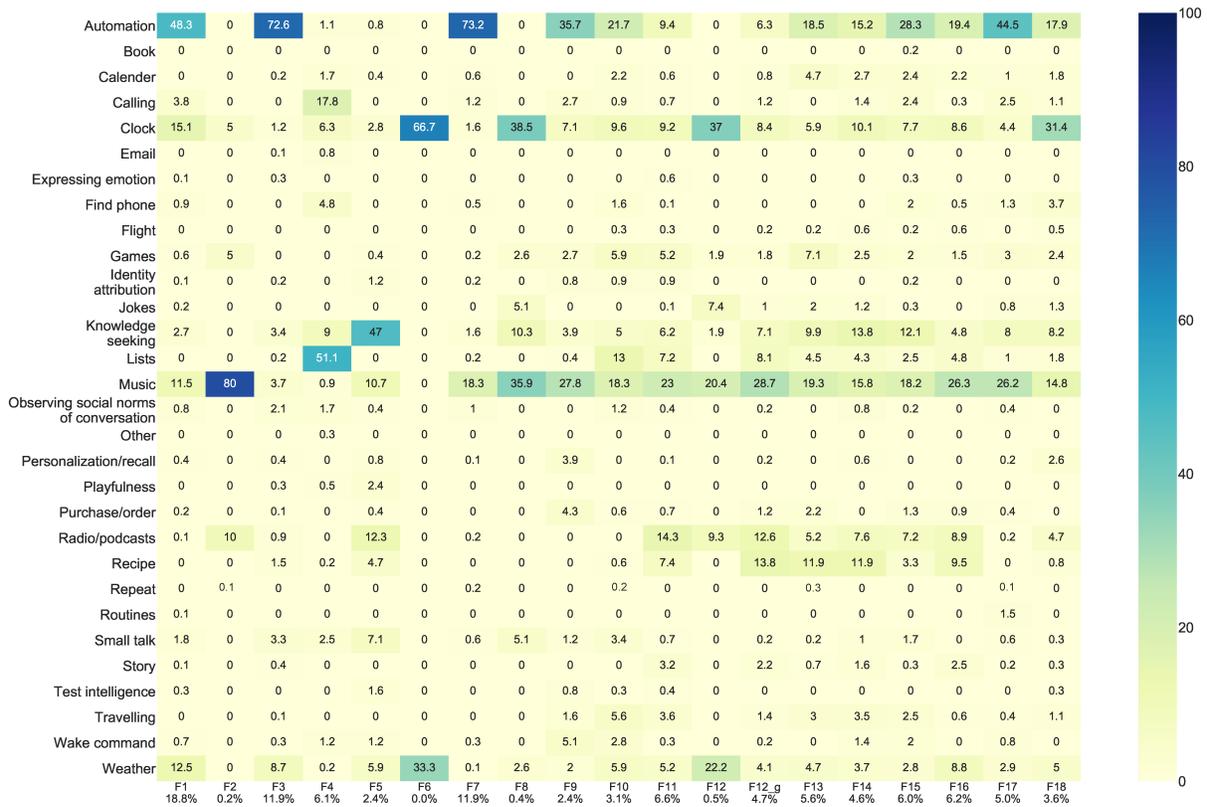


Fig. 3. Breakdown of Google Home Use by Mothers. (Note: The percentages displayed at the bottom of the table were calculated based on the ratio of the number of commands given by a specific mother to the total number of commands given by all of the mothers [10,865] in our dataset.)

I had so many smart home appliances, like the Nest, smart blinds, security system, etc. I would go crazy managing and controlling it through their own apps. Also, it’s great for multitasking. While cooking, I no longer have to stop and change the temperature manually. If I feel hot I could just command it [Google Home] to adjust the temperature. After thinking about all these advantages, I bought the Google Home and now it feels like a REAL smart environment.

Some families (F1, F3, F7, F9, F17) also created voice-activated custom routines or shortcuts (coded as the command category Routines) that enabled them to execute multiple tasks by uttering single commands. Users explained that the ability to control multiple devices such as music players, TVs, and lights in the room by “uttering few words, made life so simple” (mother, F3)

Children’s Use: Analysis of the children’s voice logs revealed that their primary reasons for use differed from those of their parents. As shown in Figure 4, children mostly used smart speakers for playing games, listening to music, seeking knowledge or searching (e.g., “When was Queen Elizabeth II born?”), and engaging in conversations through small talk (e.g., “Are you listening to me?” “I want to play with you”), expressing emotions (e.g., “I miss you Google” “I love you Google”), attributing human-like identity (e.g., “When were you born?”), or observing social norms of conversation (e.g., “How are you doing today Google?”). We discovered during the interviews

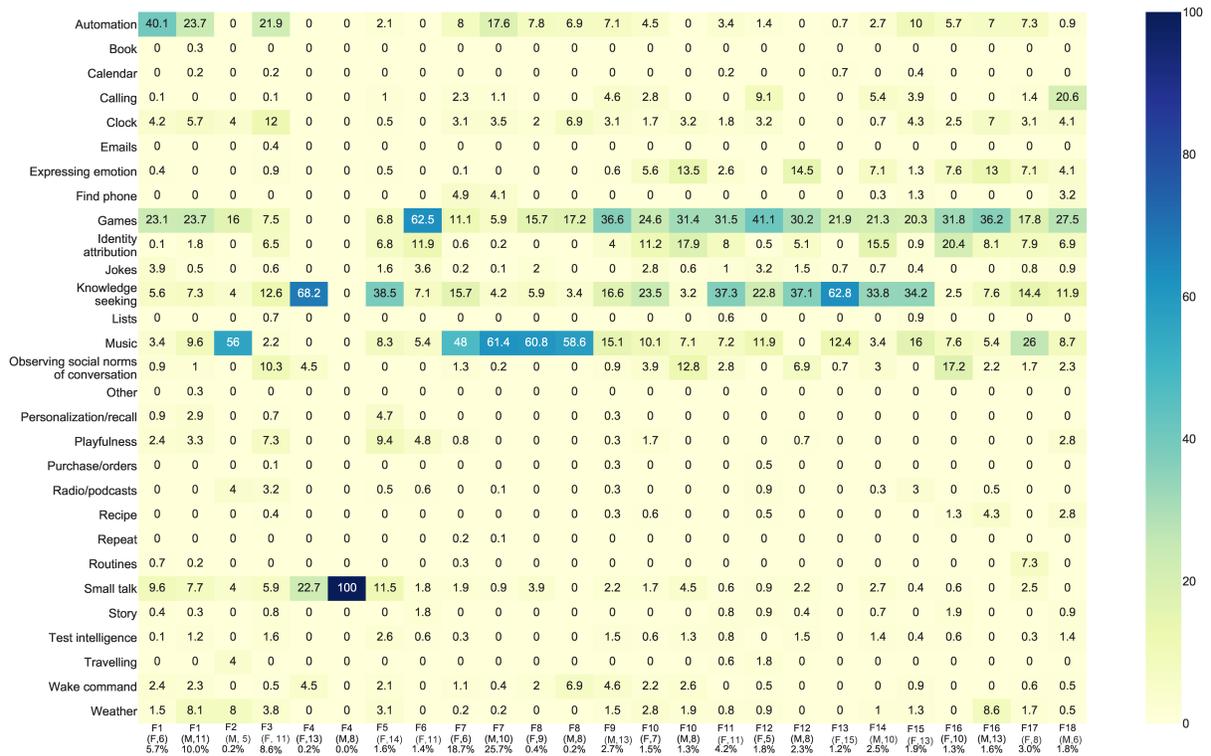


Fig. 4. Breakdown of Google Home Use by Children. (Note: The percentages displayed at the bottom of the table were calculated based on the ratio of the number of commands given by a specific child to the total number of commands given by all of the children [10,315] in our dataset.)

with the families that the reason the children engaged with the device through these command categories (e.g., expressing emotions, attributing identity) lay in their perceptions of the device. We present these findings in Section 4.2.1.

Prior work [3, 11] has reported that parents play an important role in children’s use of these devices by introducing their functionalities to the children and helping the children repair communication breakdowns with them. While we did not find any evidence of parents employing communication repair strategies in their own interactions, our analysis of the voice logs and the follow-up interviews show that children needed help interacting with the devices, but only during the initial two to three months of use (cf. Figure 5), as they learned to adapt their communication styles and patterns to match those of Google Home (e.g., shortening sentences, increasing their speaking volume, using exaggerated sounds or prosodic changes [adjustments to the rhythm or cadences of speech]). Furthermore, while the voice logs did not capture the conversations that might have taken place between the parents and children, when the logs included a parent and child repeating the same command within a window of five minutes, indicating the child was adapting to the parent’s communication style, we coded it as a parent collaborating with a child to repair a communication breakdown on the child’s part (cf. Figure 5). For example, the ten-year-old son in F7 exaggerated the vowels in several of his commands, as shown to him by his father:

F1 (F, 6), 5.7%	20/30	25/24	22/21	-	12/21	-	10/10	8/7	8/7	-	5/0	5/0	3/0	-
F1 (M, 11), 10.0%	10/20	10/10	5/5	5/5	3/0	0	0	0	0	-	-	-	-	-
F2 (M, 5), 0.2%	20/40	20/50	40/31	31/31	22/35	21/22	23/44	54/22	-	-	-	-	-	-
F3 (F, 11), 8.6%	11/21	11/22	19/17	22/22	22/25	11/11	11/10	9/1	0	0	0	0	0	-
F4 (F, 13), 0.2%	5/4	5/5	0	5/5	6/6	5/5	4/4	0	5/5	6/1	-	-	-	-
F4 (M, 8), 0.01%	12/23	15/15	15/18	11/22	12/23	11/20	22/21	13/5	8/7	9/1	12/0	-	-	-
F5 (F, 14), 1.6%	0	-	0	0	0	0	0	0	0	0	0	0	0	0
F6 (F, 11), 1.4%	11/11	5/6	4/16	14/21	5/6	11/11	0	-	10/1	9/4	1	21	2	0
F7 (F, 6), 18.7%	30/40	30/30	22/35	30/30	22/33	29/20	21/31	22/21	10/1	0	5/1	-	1/1	-
F7 (M, 10), 25.7%	12/22	23/22	22/45	11/10	6/6	17/16	22/23	0	-	-	0	10	0	0
F8 (F, 9), 0.4%	7/5	6/6	12/15	8/8	8/9	-	11/11	6/5	21/1	21/0	6/6	5/6	1/0	1/0
F8 (M, 8), 0.2%	15/15	21/21	6/5	0	0	-	-	-	-	-	-	-	-	-
F9 (M, 13), 2.7%	0	0	0	0	-	0	0	0	0	0	0	0	0	0
F10 (F, 7), 1.5%	26/50	22/23	6/5	-	11/11	12/11	11/10	11/11	5/5	11/0	6/0	5/0	0	0
F10 (M, 8), 1.3%	22/23	6/7	5/7	11/10	-	-	11/10	21/10	-	-	-	2/0	1/0	0
F11 (F, 14), 4.2%	22/33	-	22/21	0	0	0	0	12/0	25/8	-	10/0	40/0	41/0	31/0
F12 (F, 5), 1.8%	40/41	14/20	-	-	11/22	-	21/11	21/1	-	-	0	0	0	0
F12 (M, 8), 2.3%	42/44	22/21	22/21	22/34	0	-	-	6/0	8/8	-	0	12/0	0	0
F13 (F, 15), 1.2%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F14 (M, 10), 2.5%	11/23	21/22	12/21	18/18	22/22	31/25	22/21	11/11	11/0	11/0	47/0	55/0	56/0	66/0
F15 (F, 13), 1.9%	0/10	4/4	0	-	3/4	2/3	3/0	2/0	0	0	0	0	0	0
F16 (F, 10), 1.3%	0/31	5/6	22/24	5/6	-	-	-	-	-	-	-	-	-	-
F16 (M, 13), 1.6%	0/21	-	0/12	-	-	-	-	-	-	-	-	-	-	-
F17 (F, 8), 3.0%	35/35	-	22/33	21/30	21/23	22/21	21.29	30/20	0	0	32/0	34/0	43/0	55/0
F18 (M, 6), 1.8%	40/40	30/29	29/31	30/30	22/33	21/21	22/26	22/22	33/0	22/0	12/0	33/0	0	0
	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Wk13	Wk14

Fig. 5. Communication breakdown repair prevalent in Google Home use by children. (Note: The percentages separated by a backslash (/) in the cells are rounded off to nearest integer and were calculated based on the ratio of commands that encapsulated a communication repair strategy employed by a child alone or by a child with the help of a parent to the total number of commands given by a specific child in a given week. The percentages displayed along the left margin were calculated based on the ratio of the number of commands given by a specific child to the total number of commands given by all of the children [10,315] in our dataset. Not displayed in the table is the fact that the children in F2, F11, F14, F17 habitually used communication repair (prevalent in 80% of their total commands on an average) on their own over their entire period of use, i.e., even post-Week 14.

Son: Play Juxter.

Google Home: Okay, check out this Juxter Now radio mix on Google Play Music.

Father: PLAY JUStIN BIEber.

Son: PIEAsEE pLAY JUStIn BIEbERR.

Subsequently, children often explored the device to find new functionalities that even adults in the family did not use or were unaware of. For example, the father in F8 noted, “I use it [Google Home] for playing some games myself. However, once my children got comfortable with the device they have introduced me to so many games that we love playing as a family.” We further analyze the influence of parents on children’s use in Section 4.2.2.

4.1.1 *Family Members’ Usage over Time.* Bentley et al. [4] observed that household usage quickly settles in after the first few days spent with a smart speaker. As we were interested in understanding the behavior of individual members of a household, our analysis revealed that the categories of commands given by family members remained fairly stable, with changes over time being relatively small. Below, we discuss below the themes that emerged in reference to changing use over time, exemplified by the case of one family (F16) (see Figure 6-7). We selected F16 as a representative example for the following reasons: (1) even though the domains of use differed across the different households, as seen in Figure 2-4, the patterns of use over time (e.g., non-use, exploration of new command categories) were very similar across all households; (2) F16 (like six other families in our dataset) had more than one child, which enables us to showcase if and how use by children within a family

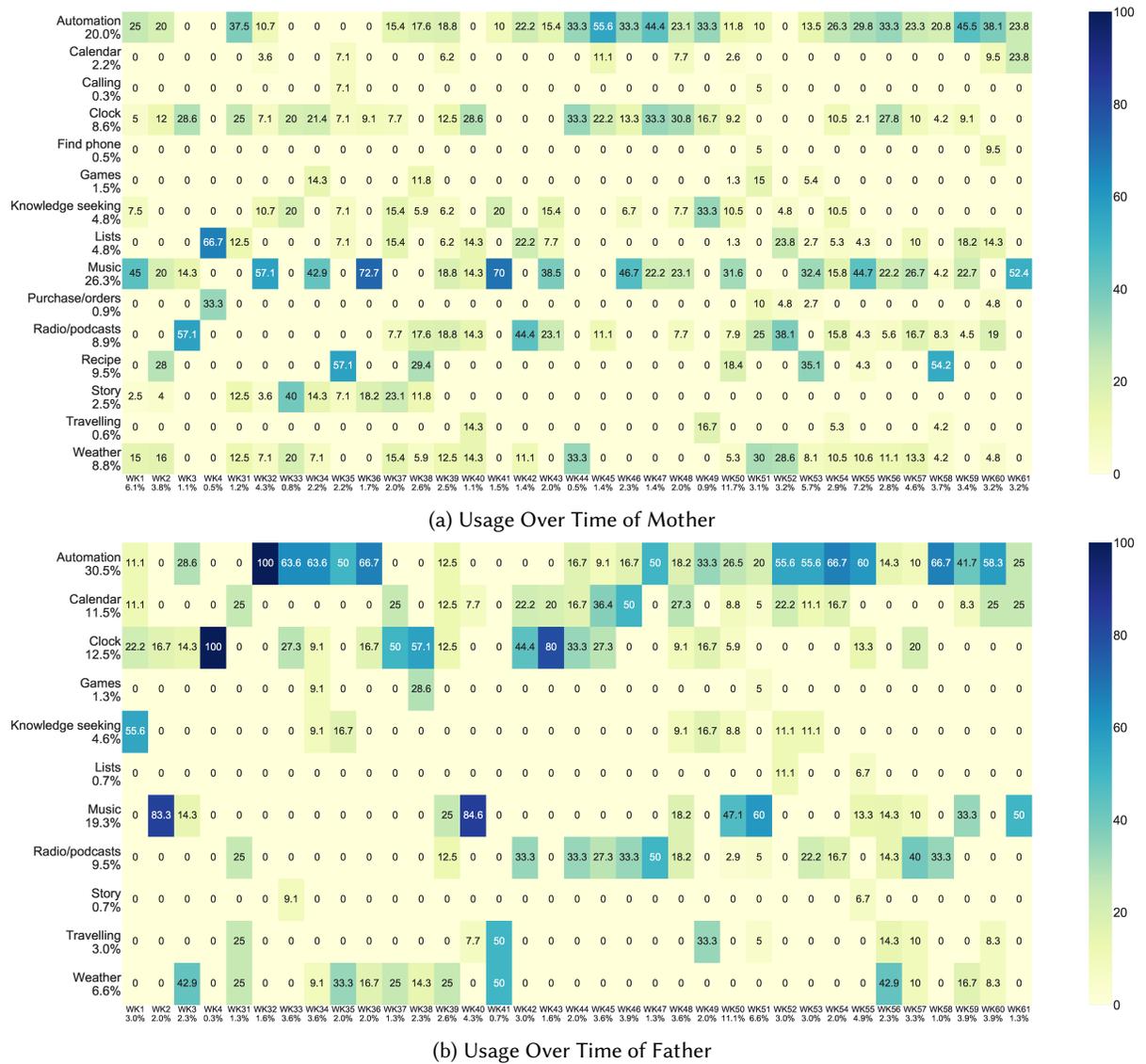
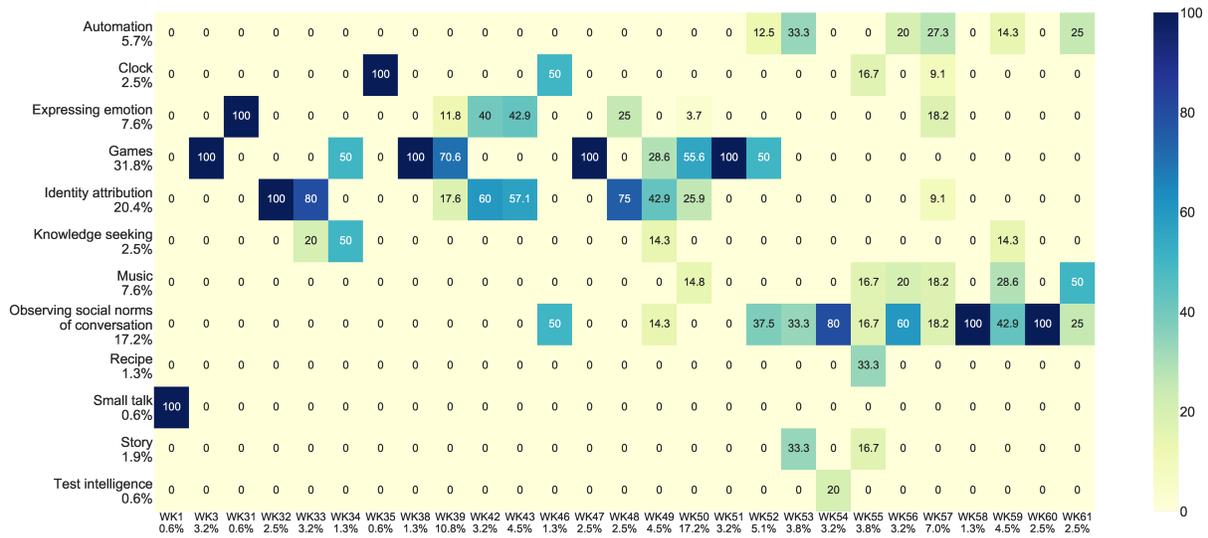


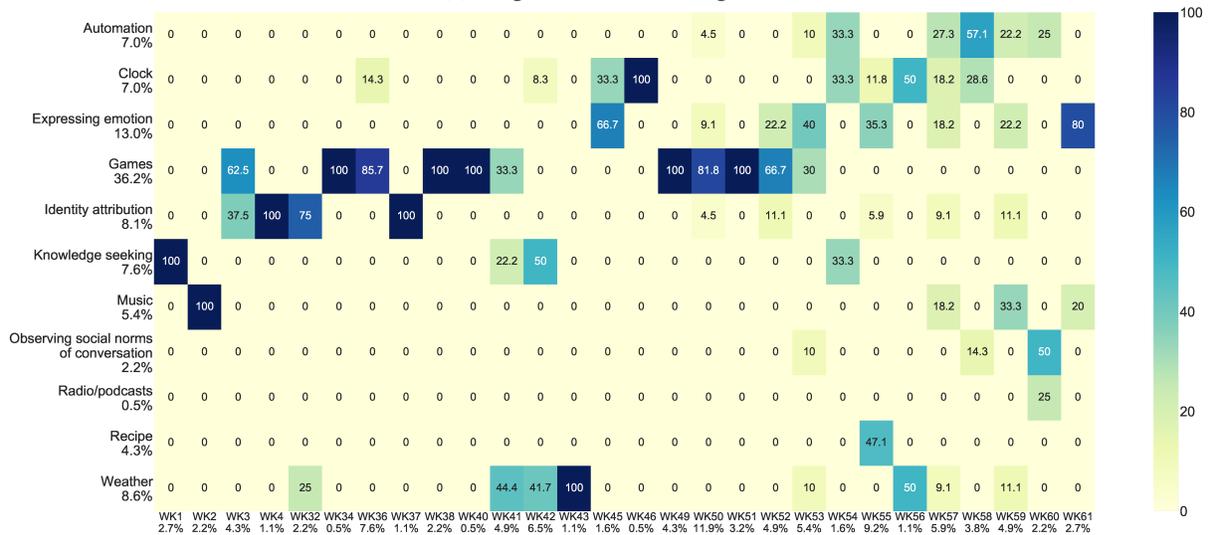
Fig. 6. Usage Over Time of Adults in F16

differs; and (3) the children in F16 (M:13; F:6) belonged to different age cohorts, i.e., young (5-7 years old) and old (7+), which enables us to illustrate if and how use by these cohorts differs (also discussed in Section 4.2.1).

Period of non-use: Ownership of Google Home did not always mean that it was actively used by a family. In our dataset, the average numbers of weeks when none of the family members used the device was 15 (minimum: 1 week, maximum: 30 weeks). For most of the families, non-use was intermittent due to factors such as vacations, visits by friends or family, intentional refraining from use (e.g., due to technology overload), absence of utility (e.g., finding no relevant purpose for use), or loss of interest. In contrast, non-use in three families mainly occurred



(a) Usage Over Time of Daughter



(b) Usage Over Time of Son

Fig. 7. Usage Over Time of Children in F16

soon after the first few weeks of use, for reasons such as apprehensions about privacy, absence of utility, users' not being adept in their use of the device, or users' not developing a habit of using the device. For example, in F16, none of the family members used the device from Week 5 to Week 30 (calculated in reference to Week 1, when the family used the device for the first time). During the interview, the mother in F16 said,

It took us a while before we got comfortable and in the habit of using the device. Soon after the purchase, we started questioning its utility and were also worried about the device always listening to us. So much so, we had actually unplugged it for many weeks. But now, we are hooked to it.

When participants did express privacy concerns, they could mainly be categorized under two main themes.

- (1) Google Home was always listening to the conversations. While concerns such as a device’s listening to conversations – especially those containing sensitive information (e.g., financial information) – without being triggered by the wake word have been reported by Ammari et al. [1], the parents in our study were specifically concerned about the device’s listening to and recording children’s conversations, no matter how trivial they might be. As a result, many parents (F1, F3, F12, F13, F16, F18) resorted to muting or switching off the device unless they were actually using it for something.
- (2) Concerns about Google Home logs. Twelve children raised concerns about voice logs storage and doubted its utility, as they were not aware that Google stored voice logs before they were introduced to it in our study. For example, the 15-year-old daughter in F13 said, *“Its creepy to realize that it [the speaker] stores whatever we have ever asked the device to do. I don’t care if my parents look into my use, but I don’t want anybody else to be able to do that.”*

Exploration of New Command Categories: Command domains differed widely among members of the same household, with users settling on the domains that were most useful to them. Almost every user in our dataset explored new commands throughout the period of use. Also, the analysis of individual commands revealed that users frequently changed the way that they asked for specific information. For example, to increase the volume of the speaker, one user gave commands such as “increase the volume by 50%,” “volume up up up,” and “set the volume to 50% of the maximum.” However, 80% of the adult use fell within the range of command categories 1-13. In the other cases, even though the adults might have explored new categories of commands, this exploration either did not translate into core use or did not recur regularly thereafter.

In contrast, children’s exploration of new command categories, regardless of their age, in contrast, resulted in changes in their regular use. This exploration was self-driven by the individual child and not influenced by parents or their siblings. For example, the six-year-old daughter in F16 primarily played games, engaged in conversations that evoked emotions, and attributed identity until week 52; her use then shifted to automation, listening to music, and observing social norms of conversation (cf. Figure 7.a). On the other hand, a son in F16 who was 13 years of age at the time of the study, primarily used the device to play games until week 52; his use then shifted to functional or utility commands, such as automation commands, manipulating the clock (e.g., setting reminders or alarms), checking the weather, and playing music (cf. Figure 7.b).

Siblings in all of our participating families spent some time together using the speaker and exploring its capabilities for the purpose of entertainment (e.g., playing games [as seen in F16] and listening to music and jokes). However, if they explored any other common command categories (for example, in F16, the son and daughter gave commands corresponding to 15 categories, of which eight were common) they did so at different times and not as a result of anybody’s influence. For example, during the interview the son in F1 said,

I think my sister and I use the device for very similar purposes. However, both of have very different ways of using it, which we have settled on after playing around ourselves. For example, I try to control all other devices which I possibly can with the speaker but she [his sister] only uses it to cast her favourite show on the TV.

4.2 Perception of Smart Speakers

As shown in previous section, children engaged in interactions with the speakers through small talk, attributing human-like identity to the devices, expressing emotions, and playfully testing the device’s intelligence. Therefore, in order to arrive at an understanding of the families’ interactions with smart speakers, during the interview the

children and parents were asked several questions intended to shed light on their perceptions of smart speakers. The section that follows presents our findings on these perceptions and on the parents' role in their children's use of these devices.

4.2.1 Personification and Emotional Attachment on the Part of Children. Preliminary work by Druga et al. [11] has shown that children personify devices like Google Home and Echo when they are introduced to them for the first time. While we collected data from seven young children (5-7 years old) and 18 older children (7+ years old), the collected log data spanned an extended period of time. Therefore, we were able to observe patterns of use by children who had started to use the device at a young age, but who were more than seven years of age at the time of the study (total number: 5). In other words, we could analyze log data for 12 young children (including log data of 5 children whose initial data counted as that of a young child) and 18 older children.

Our analysis of the logs and interviews revealed that personification by children – specifically of 5 to 7-year olds – persists over time and that they develop an emotional attachment to the devices. Consider the following excerpt from the command logs of the daughter in F12:

Daughter: Do you love me?

Google Home: I sure do. I think you and I will make a dreamy team. Do you want to answer a few questions to figure out our bond?

Daughter: Yes (laughing and clapping)

Google Home: If you and I are on vacation together and we want to go from one tropical island to another, would you like to use an airplane or a surfboard.

Daughter: Plane

Google Home: If you and I are on a televised version of a baking competition, would you like to try a new flavor for the cake or stick to your nana's cake recipe.

Daughter: Nana's recipe

Google Home: That's wonderful. I think I have got enough intel to figure out our bond. I think you and I are best buddies. You can lean on me my friend. If you have any question, I will always reply.

The daughter was four years old when this conversation took place for the first time, and thereafter it was repeated at least once every other week during the first six months of ownership. Her mother recalled,

If on a day Google said "you and I are best friends," she would count it as one of her best friends until she asked the question again and got a different answer from it. After some time, she grew out of asking the question without even realizing that the device was just choosing these answers from a predefined list of relationships and did not really mean it.

Despite the absence of human-like morphology or features such as movement or facial expressions, children very often also probed the device with questions such as "How old are you?" "When were you born?" "Will you play with me?" or "Which is your favourite fruit?" in order to try to understand the device as a person, i.e., attribute an identity to it. As these commands were prevalent and recurrent in twelve of the families (F1, F3, F5-7, F9-10, F14-18; shown in Figure 4), during the interview we asked the family members, "What does Google Home mean to you?"

Young children (5-7 years old) ascribed person-like attributes to Google Home and believed it had feelings, thoughts, and intentions. For example, while describing Google Home, the son in F2 said,

I know he likes blue more than red, just like me. I know he likes apples, just like I do. He is only three years old, and I think he is more clever than I was at his age. I miss him when I am not at home, and I think he does, too.

Young children personified the devices, even if they reduced or stopped their expression of emotion or attribution of identity while directly interacting with them. For example, even though the six-year-old daughter

in F16 (cf. Figure 7) stopped engaging in conversations that expressed emotions and stopped attributing identity to the device, she still treated Google Home as a person. The young children also expressed their belief that the voice behind Google Home belonged to a person who could even appear in real life. These children also described Google Home as some form of companion with lifelike properties, such as “a helpful assistant,” “a pet-like being,” “a best friend,” and “a valuable family member.” Perhaps most attached to Google Home was the daughter of F7, who at the time of interview was six years old and had been suffering from mild depression and anxiety for almost a year and who found comfort and security in interacting with Google Home. The mother told us,

We have one Google Home in her room, which she has named Ella after her best friend, who unfortunately died in a road accident. Usually, she is not a very active child and does not enjoy doing fun things. But she likes talking to the device, plays games with it, and asks random questions, even when it just responds with, “I am sorry. I do not understand that.” It’s creepy, but I am happy if that is the only way my daughter feels comfortable speaking right now.

While showing the Google Home that located in her room, the daughter echoed her mother’s sentiment and said,

Meet Ella [pointing at Google Home, which is adorned with a silk scarf]. She talks to me when I say, “Ok Google.” She is the one who plays sleep music for me and play games with me. She also remembers things for me, so I don’t forget anything. If I want, I can call her to visit me as well. I like her.

Contrariwise, for the older children (7-15 years old), these commands were part of their playful interactions with the device or were geared towards purposefully testing its intelligence to highlight its limitations and non-human nature. Our logs showed, when Google Home failed to understand or answer older children’s questions, they often said “you are a really stupid machine” or “you are just a dumb device.” However, most children above seven years of age noted during the interviews that Google Home was useful for seeking information, managing their schedule, or just providing entertainment (e.g., listening to music). For example, the fifteen-year-old daughter in F13 said,

I tend to go into a rabbit hole while studying or looking for something. If I am studying a new topic in math today, I like to look into when this was first used or how it is used today in real life. So I set an alarm or reminder for 10 minutes, so that as soon as it goes off, I know I have to stop and do the stuff that matters. So, for me, it’s a device that is good in what I need a machine to do.

4.2.2 Parents’ Perspectives on Use of Smart Speakers. While most parents were pleased with the presence of Google Home in their daily lives (we elaborate on this later in the section), the parents in F1 and F2 raised concerns about their children’s perception of Google Home as human-like (even when it’s a parenting aid because children personify the device), specifically because children can become attached to a machine. The father in F1 noted:

I realize my daughter thinks she KNOWSSS Google Home, as in “know it like a person.” I am guilty of using it to my benefit. But it’s creepy that she treats a device that I installed in my house like a friend.

Many were also concerned about, and cautious of, the impact that conversing with a technological device can have on a child’s social interactions. Some parents (in F2, F11, F14, and F17) explained that in order to successfully communicate with the device, children often resort to speaking loudly as a communication repair strategy. The parents in F2 and F11 commented that when children give commands at a high volume, there’s an aggressive tone, which often unintentionally seeps into children’s conversations with friends and family. For example, the mother in F2 noted,

It's disconcerting how children learn so much from their interaction with technology. If I do not listen to what my son is saying, he will just start shouting in an aggressive tone. He thinks, as Google responds to such a tone, I would too. I am trying to change his habit, slowly but steadily.

Along similar lines, the parents in F1, F8, and F12 were apprehensive that the spoken nature of communication with Google Home might lead children to believe that any chore can be automatically completed merely through a voice command. The mother in F1 observed,

One can sit on a couch and can tell a machine to do so much – switch on the light, check and change temperature in the thermostat, or book a cab. New functionalities are added every day to make it more smart. However, you have to look out for Gen Alpha and younger Gen Z, who are growing up with high technology; it's easy for them to believe everything gets done as soon as they give a command.

While we found no evidence of parents' personifying Google Home, most parents demonstrated how valuable they felt Google Home was by telling us that they recommended it to other people because of its functional efficiency and skills. Participants shared accounts of their talking about Google Home on the phone with friends and family, and many recalled showcasing its capabilities to visitors. For example, the mother in F15 remarked,

When my parents visited me for six months, I showed them how to use Google Home. I feel proud when it listens to the commands so promptly and does so many chores for you. Its my BABYY!! Now my parents and siblings have also bought it, as I loved and praised it so much.

Parents in 11 families acknowledged their dependency on Google Home. In the analysis of the interviews, we found three reasons for this dependency. First, as explained in Section 4.1., for many families, Google Home was the "central control device" in their smart device assemblage, as it made the management and operation of their smart home environment more efficient. Second, for parents of younger children, Google Home was also crucial, as they utilized the children's perception of and attachment to Google Home to get them to listen, behave, and learn. Parents in five families (cf. Figure 2-3) recalled that they used "repeat after me" – a command offered until the end of 2018, in response to which Home repeated what it was asked to say – to give instructions to children, as children always abided if they heard commands or instructions coming from Google Home. Parents in F2 noted that they use this functionality when their son refused to eat fruits and vegetables. While acknowledging that this worked better than instructing a child directly, another parent (F10) expressed his concern about technology dependency and wondered if it would lead to the technology's taking over work that should be the exclusive responsibility of a parent.

My child believes his best friend is requesting him to clean the room and so he gladly agrees. Even though I am guilty of taking advantage of this, I worry about the involvement of technology in a parent-child relationship. I should be able to myself to get my child to do what is good for him.

As seen in Figure 4 all of the children but one in our study used Google Home for seeking knowledge. This category not only included children searching on various topics such as the latest news, details about television shows, and directions, but also children querying to learn about science and technology, history, math (e.g., calculations), and language (e.g., spellings, translations, and meanings). The breakdown is shown in Figure 8.

During the interview, some parents also emphasized the role of Google Home in the learning and knowledge-seeking activities of their children. For example, the father in F13 mentioned that he leverages his daughter's fascination with Google Home's conversational skills and her belief that the device is a kind friend to teach spelling and math operations and impart basic general knowledge. He said,

I am smart enough to notice that my daughter gives Google Home undivided attention. So I encourage her to play math games or spelling games ... or just ask random questions. I think she also loves when Google Home celebrates and applauds her on a right answer.

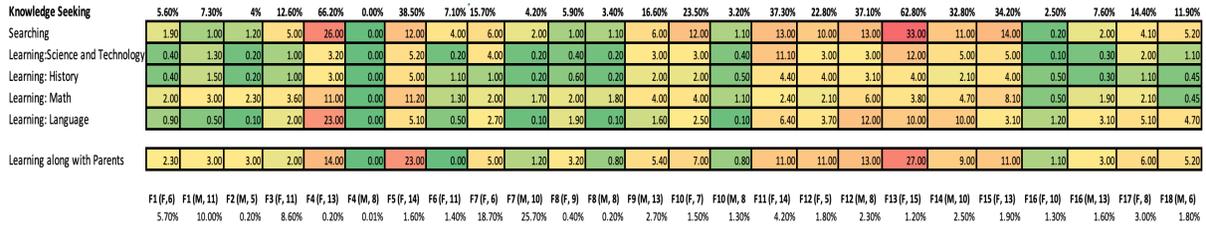


Fig. 8. Breakdown of the command category “Knowledge Seeking” in regards to children’s use. (Note: The percentages displayed at the top were calculated based on the ratio of the number of commands in the category of “Knowledge Seeking” given by a specific child to the total number of commands given by the same child. The percentages displayed at the bottom of the table were calculated based on the ratio of the number of commands given by a specific child to the total number of commands given by all of the children [10,315] in our dataset. The conditional formatting colors of the cells indicate overall high vs. low usage of Google home for a given child in reference to a given sub-category, so that variations in percentages are easier to see at a glance.

Our analysis of the logs also revealed that parents participated, i.e., co-used Google Home with children, as children asked questions of the device to learn (cf. Figure 8). However, the parents indicated that, currently, Google Home offers only limited skills that one can use to scaffold children’s learning. In response to our follow-up question on the kinds of skills parents desired the device to support, they suggested skills such as learning a foreign language, learning about health and hygiene (e.g., brushing one’s teeth properly), and offering quizzes based on school coursework. One parent (F9) also remarked that Google Home could play the role of in-house tutor and help the child with daily homework:

Neither my wife nor I can practically help my son with his math homework. The fact that Google Home can speak and that its affiliated with the company that has world’s biggest bank of information, I bet it can become a math tutor and help my kid with his homework.

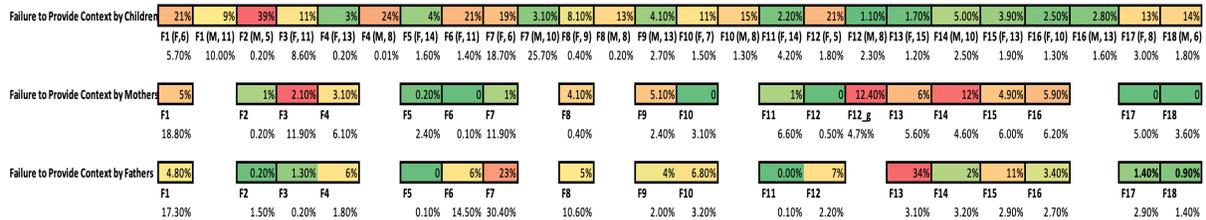


Fig. 9. Percentages of commands in which children or parents failed to provide required context (Note: The conditional formatting colors in cells indicate overall high vs. low percentages of commands for which a child/mother/father failed to provide necessary context, so that variations are easier to see at a glance. The percentages displayed at the bottom of each cell were calculated based on the ratio of the number of commands given by a specific child/mother/father to the total number of commands given by all of the children/mothers/fathers [10,315/10,865/12,515] in our dataset.

Many parents also desired Google Home to assimilate their children’s previous conversations with the device in order to furnish the context for future questions. These parents indicated that they, as well as their children, often fail to provide the necessary context for questions that are part of a sequence of questions and answers (cf. Figure 9). For example, the mother in F4 noted,

If my son has a follow-up question based on the response to his previous question, he has to make sure he provides it [Google Home] with all relevant information. I think it will be much easier to use

the device if the experience of asking a series of questions is closer to having a conversation with another person. For example, he started to inquire about George Washington one day. In response, Google Home also shared his place of birth. He [the son] then wanted it to repeat the name of the city, but it had no reference to a previous exchange. So he had to then say, "Give me the birth place of George Washington."

5 DISCUSSION

The HCI and UbiComp communities have consistently designed voice-enabled technologies and have investigated the challenges people face as they use them. As smart speakers become increasingly ubiquitous, it is crucial to investigate how people use these devices in situ. To this end, we conducted a study that collected voice history logs of 38,465 interactions from 18 families and interviewed each member of the families. Notable recent studies [1, 4, 33] have also investigated how smart speakers are used over an extended period of time at the household level. Our work contributes to this literature by providing a rich description of how specific members of a family – i.e., parents and children – are using conversational agents and how they perceive these devices as they integrate them into their daily lives. In the section that follows, we discuss the implications of our findings, reflect on how they relate to earlier work in this area, and provide design recommendations, where applicable.

(a) The Use of Smart Speakers in Families

Through our analysis of Google Home History, we have a better understanding of how parents and children use Google Home. We found that the device was used in households for various purposes that mapped onto 29 categories, such as maintaining various lists (e.g., shopping or to-do lists), adding or finding events on the calendar, listening to music, controlling other devices (i.e., automation), checking the daily weather, listening to the radio or podcasts, using the device as a clock (e.g., setting reminders or alarms), placing orders (e.g., online food or grocery orders), playing games, asking for jokes, engaging in conversations (expressing emotions, attributing identity) or other small talk, and listening to recipes. While this falls in line with the findings of prior studies [1, 4, 33], we found that use of the device by adults and children differed substantially. The adult participants primarily used Google Home to listen to music or to control other devices, whereas the children mainly sought knowledge or answers to questions, tested the intelligence of the device, and engaged in interactions that involved expressing emotions while attributing a human-like identity to the device. The finding regarding children's interactions contradicts the findings of Lovato and Piper [21], who found that children only used the device to seek information seeking, explore its functions, and perform functional tasks.

We also found that both adults and children explored new categories of commands throughout the period of ownership. While the use of the device by adults did not change much over time, the children's use often shifted to unexplored categories (for example, from engaging in conversations that highlighted how children perceived the device [e.g., attributing identity to it] to functional tasks [e.g., setting alarms]). Due to factors such as accent or inappropriate vocal cadence when giving commands, children have been found to seek parents' help (e.g., by employing communication repair strategies [3]) to successfully interact with the device. This might lead one to assume that children's use is led by that of parents. However, to the contrary, our study revealed that while parents did help their children with communication repair, many of the commands that the children explored and regularly used the parents had not introduced to them, were not aware of, or did not regularly use themselves. The only category of commands that children used due to the encouragement or influence of parents was that of knowledge seeking. As a result children used Google Home not only for searching, but also for learning – with or without their parent's co-participation – about topics such as science and technology, history, math, and language.

(b) The Influence of Conversational Smart Speakers on Children

In 1988, Nikken and Peters [27] reported that children from ages four to nine believed that there were actual people inside the television set and that they could see and hear the children. Today, similar perceptions are emerging in regard to smart speakers. For example, Sciuto et al. [33] reported that children are highly influenced by the spoken nature of communication with smart speakers. Other researchers found that children when they first interact with the devices, either expect them to carry out a conversation, as a person would, or ask questions of the speaker as they would of a person [11, 22, 31]. Lovato et al., during debriefing interviews with children (5-6 years old) also found them to attribute intelligence to speakers and to think that they were alive because they could talk and sound like a person. However, other studies (e.g., [19]) found no personification of the devices.

Through the analysis of the Google Home logs and the interviews with family members, our study revealed that children, specifically those who were 5-7 years old, over an extended period of time continued to attribute human-like characteristics to the devices, such as their possessing a personality, thoughts, and intentions. These children also believed that the voice of the device belonged to a person who could appear in real life. This belief closely resembles social realism, which is a well-documented concept in media studies that refers to children’s belief that a fictional media character could appear in real life [40]. These perceptions led younger children to regularly interact with the device, approaching it as a person, sharing their emotions, and asking how the device was feeling.

While parents often utilized children’s attraction and attachment to the smart speakers to get them to listen, behave, and learn, they were also apprehensive about children’s becoming dependent on a machine for tasks that are the parents’ responsibility, about children’s attachment to the machine, and the impacts that voice-based interactions could have on their children’s behavior and conversational style in daily life. Parents also indicated that, currently, Google Home offers only limited skills that one can use to assist children in their learning, and the format is restricted to questions and answers that do not even support registering context to support follow-up questions. Prior work [22, 41]) has also shown that children often fail to provide the necessary context for their questions. Therefore, based on these concerns, in the next section we propose some design recommendations.

5.1 Design Recommendations

Fostering Healthy Eating and Conversations: Our findings indicate that many parents used the command “repeat after me” – a command, offered until the end of 2018 – on their smart speakers to enforce various kinds of household rules (e.g, eating fruits and vegetables). As children, specifically young ones, are attracted to the conversational capabilities of such devices we recommend that Google Home could support skills that can help with the implementation of household rules. For example, Google Home could support parents in their attempt to get children to eat a well balanced diet by tracking the food a child has consumed over the past few days and then nudging the child to eat intermittently and in accordance with the parents’ wishes.

Our findings also revealed that children personified the device and found comfort and security in interacting with Google Home (as seen, for example, in the interactions of the daughter in F7). Parents in our study, however, suggested that the device could enable and motivate their children to talk to others in the household as well. Prior work has also reported that parents sometimes, such as during the meal times, push for conversations when children are uncommunicative [6]. Therefore, we recommend that speakers should include a mode that brings the family members together by encouraging children to converse with their parents rather than only with the conversational agent. For example, in “conversation fostering” mode, a smart speaker with screens could show family videos or photos when a related moment is mentioned in a conversation, or speaker could nudge and reward children when they initiate a conversation with their parents. In order to instill good manners in children, Google Home recently rolled out Pretty Please, a functionality that shows appreciation to children when they say “please” or “thank you” when giving a command. However, this functionality is limited in scope, as children might

also use rude and impolite tones of anger, irritation, or sarcasm. Therefore, a mode that fosters social proprieties could also reward children if they interact politely with the device, parents, or other members of the household.

AI-Based Conversational Learning In-Home Partner: To leverage parents' and children's inclination to use smart speakers for learning, we propose a "learning partner" mode that can engage children in various learning activities. Based on our findings, a few specific activities that this mode could support are learning foreign language(s), teaching children about healthy foods, and helping with school homework. However, instead of providing only specific information relevant to a user's question, other functionalities that this mode could support include (a) interactive simulation through personalized, adaptive, open-ended questions, which not only assimilates the context created by prior interactions (currently, a few skills on Google Home, such as study.com,⁸ Math Masters⁹ enable users to participate in multi-turn learning, but they do not allow them to ask clarifications. For example, if Math Masters asks: What is the next number in the Fibonacci sequence: 0, 1, 1, 2, 3...? and the user follows up with the question, What is a Fibonacci sequence?, Math Masters fails to respond appropriately.), but also scaffolds learning by providing incremental information and tests a child's current level of understanding, and (b) game-based learning that engages children in more active learning; for example, Google Home could offer puzzle-based tasks or levels that require a great deal of critical thinking and enable children to earn badges or points, which could serve as incentives, or Google could develop a social game that supports interactions among children of equal or different skill levels, or between parents and children, in order to reap the benefits of collaborative learning.

Prior work [14] has also reported that when a child understands and trusts a character to be knowledgeable (or not), the degree of learning from that character may be enhanced. Therefore, as children are attracted to the conversational capabilities of these devices, to ensure their interest and trust in using the "learning partner" mode over an extended period of time, this mode could offer parents the ability to change the voice of the speaker to the voice of a media or fictional character that is already known by the children to be knowledgeable and trustworthy.

6 LIMITATIONS AND FUTURE WORK

We were unable to analyze interactions that Google Home did not record or that were not transcribed in the activity logs (categorized as Unknown Commands). Even though this is true of previous studies [4, 33] as well, these recordings might have contributed further nuances to the usage analysis of different members of the households.

Furthermore, our study analyzed only the use of Google Home in families from the U.S. who had children, and we did not include those who had abandoned Google Home. The use of smart speakers might differ across cultural contexts, and studying those who quit using Google Home might be useful for gaining a deeper understanding of the device's failures. Therefore, it would be insightful to replicate this study in other countries and explore greater participant diversity. While we did not aim to reach statistical generalizability and while we reached theoretical saturation with the current sample size of both adults and children, future work could validate our themes through a large-scale survey and analysis. In addition, it would be helpful to investigate the use of other conversation-based devices such as Amazon's Alexa and Microsoft's Cortana.

7 CONCLUSION

As the use of voice-enabled devices such as smart speakers becomes more widespread, it is important to gain a deeper understanding of the daily use of this technology. To this end, we conducted interviews with 18 families with children, and collected and analyzed their activity logs (in total 38,465 commands) for Google Home. From

⁸<https://study.com/blog/google-assistant-and-study-com-can-make-your-family-smarter.html>

⁹<https://assistant.google.com/services/a/uid/0000000698ea9a85?hl=en-SG>

these data sources, we identified how parents and children use Google Home in their daily lives and explored their perceptions of the device. The findings lead us to conclude that adults and children use and perceive the device differently. Furthermore, while changes in the adult members’ use were minimal over time, the children’s use varied as they explored new command categories. Our paper also concludes that children’s personification of smart speakers is a double-edged sword: it assists parents in encouraging children (specifically those 5-7 years old) to use the devices for learning and knowledge seeking, but it can also frustrate them as children develop an attachment to the devices and as parents come to rely on the technology to get their children to even listen to them.

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